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Internal Parasites of Cattle

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INTRODUCTION

Like all other domestic animals, cattle are affected by various kinds of external and internal parasites. External parasites and their effects upon the infested animals are easily observed and because of this, a number of extensive campaigns, national or regional in scope, have been and are being conducted for their control and eradication. Where no such campaign has been instituted, the infested animals usually receive individual attention.

The internal parasites, however, are more insidious in action and are not so easily observed. When present in sufficient numbers, they manifest their presence by clinical symptoms indicative of systemic disturbance. Unfortunately, these clinical symptoms are often confused with and ascribed to other conditions. Serious outbreaks of parasitism, especially affecting young cattle, have been reported from different parts of the United States, but there is no accurate information concerning the extent of parasitic infestation in cattle and the effect of infestation in which no clinical symptoms occur. As a whole less is known about parasites of cattle than about parasites of sheep and swine. This is due, at least in part, to the high cost of cattle as

experimental animals and the large amount of space required for conducting experiments on them. In the following pages specific information is given, when available. Pending the results of further research, some gaps in knowledge are temporarily bridged by reasonable deductions based on knowledge of closely related parasites in other animals.

IMPORTANT INTERNAL PARASITES OF CATTLE

The important internal parasites of cattle are roundworms, tapeworms, flukes, and protozoa. The essential facts of the life histories of these parasites are reasonably well known although in some instances specific details concerning phases of the life cycle still remain to be ascertained. Knowledge concerning the actual damage caused by some of these internal parasites has become well established; in the case of other parasites it is still very limited. However, it is always safer to assume that parasites are injurious than to assume that they are harmless.

GENERAL FACTS CONCERNING LIFE HISTORIES

The life histories of all the common roundworms of cattle, with the exception of two, discussed elsewhere in this circular, are direct; that is, no intermediate hosts are required for their development.

All roundworms reproduce by means of eggs. The eggs of roundworms parasitic in cattle pass out in the manure of infected animals and, with few exceptions, develop on pasture into infective larvae in periods varying from a few days to a few weeks, depending on conditions of temperature and moisture. In warm weather the eggs hatch in a few hours. In the case of lungworms, the eggs hatch in the lungs and the larvae, after being swallowed, are discharged with the feces. If the temperature is below 40° F., the eggs remain dormant; if below freezing, the vitality of many of the eggs is destroyed in the course of time. Dryness also destroys their vitality; moisture, on the other hand favors their development.

The larvae which hatch from the eggs are microscopic in size. In their early stages they, like the eggs, are very susceptible to freezing and drying. In very warm weather the larvae complete development in from 2 to 4 days. In cooler weather the time required for development is longer; at temperatures below 70° F., 10 days to several weeks may be necessary. The eggs and the larvae of these roundworms, in their early stages, do not develop when ingested by cattle. Only when the larvae have reached the third stage do they become infective to their host.

In the infective stage, the larvae of many different species of roundworms become active whenever the air is saturated with moisture, as from rains, fogs, and dews, and migrate to grass stalks or other plants. When the air becomes dry and the moisture evaporates from the grass, the young worms cease their activity and resume their migrations only when the air again becomes laden with moisture. Unlike the eggs and the early larval stages, larvae which have developed to the infective stage are usually able to survive long periods of freezing and dryness. When the infective larvae are finally swallowed by their

host, they reach maturity and begin producing eggs in from about 2 to 6 weeks after ingestion.

Unlike the roundworms, which usually have a direct life history, tapeworms, flukes, and some of the protozoan parasites of cattle require intermediate hosts for the completion of their life cycles.

GENERAL PREVENTIVE MEASURES

Preventive measures for any parasitic condition are based upon a knowledge of the life cycle of the parasite involved. If the parasite is one that requires an intermediate host for the completion of its life cycle, knowledge of the life cycle of both parasite and intermediate host is necessary.

Practically all roundworms parasitic in the lungs and alimentary tract of cattle infect their host when the animal is grazing on infested pasture. It is, therefore, obvious that the best method of avoiding infection is to prevent the host animal from ingesting infective larvae. This may be accomplished as follows:

Young animals are, as a general rule, the greatest sufferers from parasitic infestations, and one's first efforts should be directed towards their protection. This is the underlying principle of sanitation. In areas where parasites are prevalent, calves should be kept away from infested pastures at least for the first 6 months of their lives. They should be raised either in the barn, in dry lots, or on pastures on which no cattle, sheep, or goats have grazed for from 4 to 6 months. The calves should, of course, be well fed and cared for in order that they may make the greatest possible gains during that period.

The second point of attack lies in the prevention of pasture contamination. As animals can become infested only by swallowing infective eggs or larvae, and as such larvae can develop only from eggs passed in the manure of infested animals, all measures which may diminish the number of eggs passed out of the body of the host should be used. This means that on farms where calves suffer regularly from parasite infestations, either when pastured with older animals or on areas on which older animals such as cattle, sheep, or goats have grazed, not only the visibly affected calves but also the older animals should be examined and treated when necessary. As most animals are subjected to continuous reinfestation from parasitic material on pasture, treatment should be administered regularly. Field experiments conducted in different parts of the country have shown that in order to give best results treatment should be administered, wherever possible, once every 2 or 3 weeks, as indicated, during the summer, and once every month during the winter. It is always advisable to call in a veterinarian to administer these treatments to livestock as all drugs which will kill internal parasites are more or less dangerous and should be given in doses based on the age and condition of the animal or withheld if treatment is not advisable.

A third point of attack is the pasture itself. As moisture is one of the necessary factors in the development of the eggs and larvae, only well-drained areas should be selected for pastures, whenever the nature of the land is such as to permit a choice. In sections of the country where the contour of the land permits no such choice, proper, artificial drainage should be provided for wet pastures.

In fluke-infested areas preventive measures are directed against the snails which serve as intermediate hosts of the flukes. It has been recently ascertained that certain free-living beetle mites serve as intermediate hosts for the tapeworms of cattle and sheep; however, no preventive or control measures can be recommended because very little is known of the life history and habits of these mites.

In the case of disease-producing protozoa, measures for the destruction of those insects which serve as intermediate hosts, transmitters or carriers, are indicated.

GENERAL SYMPTOMS OF WORM INFESTATION

The general symptoms of worm infestation are roughened hair coat, unthriftiness, loss of flesh, diarrhea, absence of fever, anemia, manifested by paleness of the visible mucous membranes of the eyes and mouth, shortness of breath, development of "pot belly" or enlargement of the abdomen, especially in young animals, and often a soft swelling under the jaw known as "bottle jaw" or "poverty jaw."

ROUNDWORM PARASITES OF THE ABOMASUM OR FOURTH STOMACH

The Twisted Stomach Worm

Location.—This worm, *Haemonchus contortus* (fig. 2, *F*), occurs in the abomasum or fourth stomach.

Appearance.—The worm is from ¾ of an inch to 1½ inches long and about as thick as a pin. The females are larger than the males and when alive, the body is marked with a spiral striping, which is responsible for the common designation of "twisted" stomach worm. On post mortem examination of animals that have died of stomach worm disease, these parasites may be found, sometimes in enormous numbers, in the fourth stomach.

Distribution.—The twisted stomach worm, *H. contortus*, has been reported from cattle in widely scattered areas in the United States but appears to be particularly prevalent in the South Central and South Atlantic States especially those bordering on or adjacent to the Gulf of Mexico and in Puerto Rico.

Life history.—The life history of this parasite (fig. 1) is discussed under General Facts Concerning Life Histories.

Symptoms.—Usually the first thing noticed about animals suffering from infestation with stomach worms is a lack of thrift. There is no gain in weight in spite of good feeding, the hair coat is rough and staring, and the animal appears listless. There is a marked anemia, manifested chiefly by paleness of the visible mucous membranes of the mouth and eyes. There is often a marked swelling on the under side of the jaw. In most cases there is no fever.

Lesions.—The post mortem examination often shows a marked swelling of the wall and leaves of the fourth stomach. The remainder of the carcass presents an anemic appearance, the blood is thin and watery, and there is often an extensive gelatinous infiltration of the tissues.

Treatment.—The treatment for stomach worm infestation consists in the administration of a 1-percent copper sulfate solution in the following doses: Calves, 3.5 to 4 ounces; yearlings, 6 to 8 ounces; 2-year-olds and over, 16 ounces to 1 quart. This solution may be prepared by dissolving one-quarter pound of copper sulfate, or bluestone crystals, in 1 pint of boiling water, then adding enough water to make 3 gallons of solution. Porcelain or enamelware receptacles should be used to prepare this solution as copper sulfate will corrode

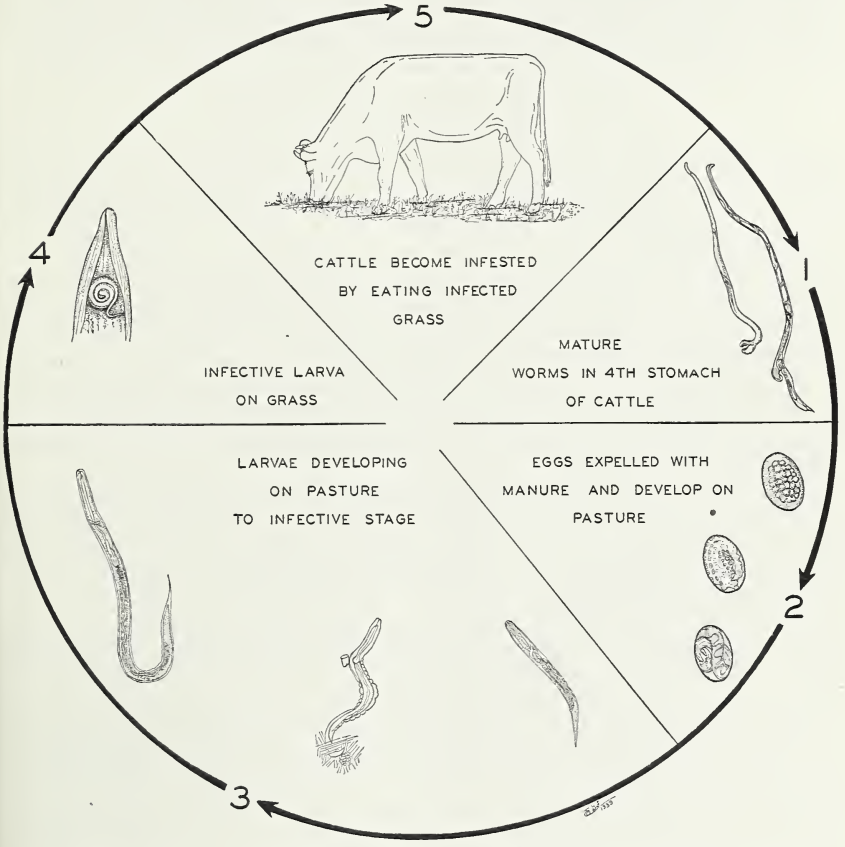

Figure 1.—Life cycle of the common stomach worm, *Haemonchus contortus*.

metal. The solution may be given in a drench or it may be administered with a 4-ounce metal syringe.

A solution of copper sulfate and nicotine sulfate is also an effective treatment for the twisted stomach worm. This solution may be made up by adding 1 ounce of 40-percent nicotine sulfate to each gallon of a 1-percent solution of copper sulfate. The combined solution may be used in the same doses as the 1-percent solution of copper sulfate. However, the combined solution is somewhat more poisonous for cattle than is the 1-percent solution of copper sulfate. If there is any doubt as to the ability of the animals to tolerate the above-mentioned doses, the dose should be reduced accordingly.

Phenothiazine administered in gelatin capsules at a dose rate of 30 grams (approximately 1 ounce) for calves and yearlings and 60 grams (2 ounces) for older animals, may also be used in the treatment of cattle for stomach worms. In a limited number of experiments this drug has been found to be effective in the treatment of cattle for stomach worms, hookworms, and nodular worms.

Another species of *Haemonchus*, namely, *H. similis*, has been found in cattle in Florida, Louisiana, and Texas. It is probable that the information given concerning *H. contortus* applies also to *H. similis*.

PREVENTION.—Infestation by this parasite may be avoided by following the procedures given under General Preventive Measures.

THE MEDIUM STOMACH WORM

LOCATION.—This nematode, *Ostertagia ostertagi* (fig. 2, *I*), develops in the wall of the fourth stomach and when mature is found in the cavity of the stomach, usually in the end which opens into the small intestine, known as the pyloric end.

APPEARANCE.—It is a hairlike worm less than one-half inch in length. When freshly collected, it is reddish brown in color.

LIFE HISTORY.—The life history of this stomach worm is not known in detail, but it is probably similar to that of *Ostertagia circumcincta*, a closely related species found in the fourth stomach of sheep. Studies of the life history of *O. circumcincta* have shown that the infective larvae on reaching the fourth stomach, about the third day after ingestion, penetrate into the wall of this organ and develop into adult worms in about 15 days.

DISTRIBUTION.—The medium stomach worm has been found in a large percentage of cattle examined in Louisiana and Texas. It has also been reported from Kansas, Oregon, Illinois, Maryland, New York, and Virginia. It is probably distributed throughout the United States rather generally.

SYMPTOMS AND LESIONS.—As a result of the penetration of the larvae, the wall of the fourth stomach becomes marked with small, elevated, inflamed hemorrhagic areas.

The most noticeable clinical symptoms exhibited by severely infested animals are emaciation, anemia, as shown by the marked pallor of all the visible mucous membranes, edema of the submaxillary region, and a profuse, watery diarrhea. The temperature may remain normal or be slightly increased. The appetite may remain unimpaired but thirst is increased, as might be expected in animals suffering from severe diarrhea.

On post mortem examination the carcasses of animals that have died as a result of infestation with *Ostertagia ostertagi* show marked emaciation and anemia. The mucosa of the abomasum or fourth stomach is swollen and edematous and may contain many nodules of various sizes.

TREATMENT.—Tetrachlorethylene administered in hard gelatin capsules at a dose rate of 5 cubic centimeters for each 100 pounds of live weight is of value in removing the worms which are free in the stomach contents. The drug should be administered after fasting the animal for 24 hours. To control heavy infestations, it is necessary to repeat this dose every 2 weeks. Tetrachlorethylene may be followed immediately by sodium sulfate (Glauber's salt) given in capsules or in solution

in water in a dose of 2 ounces for young calves up to 1 pound for full-grown animals. Tetrachlorethylene should not be given to animals suffering from febrile diseases, and doses should be diminished for those suffering from emaciation or debility.

Phenothiazine may be used also for the removal of the medium stomach worm, with the same dosages as are described for the twisted stomach worm.

Another species of *Ostertagia, O. lyrata,* has been found in cattle in Louisiana and Virginia. The information given concerning *O. ostertagi* also applies to this species.

PREVENTION.—Preventive measures as described under General Preventive Measures are effective in controlling this parasite.

THE HAIRLIKE STOMACH WORM

LOCATION.—Another roundworm occurring in the stomach of cattle is *Trichostrongylus axei* (Syn. *T. extenuatus*) (fig. 2, *H*).

APPEARANCE.—This is a very small, hairlike worm about one-fourth inch long. Because of its size it is generally overlooked, as it is practically impossible to distinguish it in the contents of the ordinary cattle stomach except by careful examination in the laboratory.

LIFE HISTORY.—While the life history of this particular species has not been worked out experimentally it is probably similar to those of the related species, *T. colubriformis* (fig. 2, *C*) and *T. rugatus,* the life histories of which have been ascertained. In the case of *T. colubriformis* and *T. rugatus,* the free-living larvae can develop to the infective stage in a minimum of 60 hours and the parasites can mature in the stomach in about 17 to 21 days after being ingested by the host animal. At the end of this time eggs begin to pass out with the manure.

SYMPTOMS AND LESIONS.—In addition to causing general symptoms of worm infestation, this worm has been held responsible for a severe gastro-enteritis or inflammation of the stomach and intestines and for diarrhea in calves, but no experimental work has been done in the United States to determine its effect on cattle.

PREVENTION.—Infestation with this parasite may be prevented by following the procedures given under General Preventive Measures.

TREATMENT.—Repeated treatments with tetrachlorethylene as outlined above are suggested for controlling infestations with this worm. Experimentally, phenothiazine also has been found to be an effective treatment.

PARASITES OF THE SMALL INTESTINE

THE CATTLE HOOKWORM

LOCATION.—This worm, *Bunostomum phlebotomum* (fig. 2, *N*), when present, is usually confined to the anterior portion of the small intestine.

APPEARANCE.—The cattle hookworm is a relatively large, white worm. The male is about ½ inch and the female about ¾ of an inch to 1 inch long. The worms are about one-half to three-fourths as thick as an ordinary pin.

LIFE HISTORY.—The preparasitic or free-living stages of this nematode are similar to those described for the group of roundworms known

as strongyles of cattle, but the mode of entry of the infective larvae into the body and subsequent development are not known with certainty. This worm belongs to the hookworm family. The larvae of many members of this family enter the body of the host by penetrating the intact skin. After penetrating the skin the larvae enter the blood vessels and are carried by the blood stream through the right side of the heart to the lungs. After spending some time in the lungs they are carried up the bronchi and trachea to the pharynx, and are swallowed. They then pass down the gullet through the stomach to the small intestine where they mature.

Although laboratory experiments on guinea pigs appeared to indicate that the cattle hookworm larvae are not skin penetrators, it has been reported that they can gain entrance into the bodies of cattle by penetrating the intact skin. It has been shown also that the infective larvae of the closely related hookworm of sheep, *Bunostomum trigonocephalum* can infect sheep by skin penetration. In the case of the sheep hookworm the time required for the worm to reach maturity after skin penetration was found to be about 10 weeks. Many of the infective larvae are, undoubtedly, swallowed in grazing, but even in this case it is possible that they make their way to the blood stream from the digestive tract and return by way of the lungs again before developing to maturity. It is also possible that the larvae, after being swallowed in grazing, develop to maturity in the intestine without previous migration, in a manner similar to that described for the dog hookworms, *Uncinaria stenocephala* and *Ancylostoma caninum*.

Distribution.—The cattle hookworm has been found in Texas, Louisiana, Mississippi, Florida, Virginia, and Maryland and is probably well distributed through the United States, especially in the South.

Symptoms.—The symptoms of infestation with this parasite are the same as those described under General Symptoms of Worm Infestation.

Lesions.—The lesions caused by this parasite are small, red hemorrhagic spots at the points of attachment in the small intestine. The general effects are described under General Symptoms of Worm Infestation.

Treatment.—According to the Oklahoma Experiment Station, the combined copper sulfate and nicotine sulfate solution, as used for the treatment of stomach worms, has proved effective for the removal of hookworms. This solution is prepared by adding 1 ounce of a 40-percent nicotine sulfate to 1 gallon of 1-percent copper sulfate solution. The dose is the same as that given for the treatment of stomach worm infestation. Tetrachlorethylene is fairly effective also against cattle hookworms. Although it will not remove all the worms, it has been found effective in removing enough worms to stop death losses and restore emaciated animals to a condition of relative thriftiness.

Phenothiazine has been found to be effective in the treatment of cattle hookworms. For correct dosages see those described for the twisted stomach worm.

Prevention.—Infestation of cattle with hookworms may be prevented by following the procedures given under General Preventive Measures.

The Cooperias

The three species of *Cooperia* commonly found in cattle are *C. punctata*, *C. oncophora*, and *C. pectinata* (fig. 2, *E*, *L*, and *K*, respectively). No common name has been established for this parasite.

Location.—These three worms are sometimes found in large numbers in the small intestines of cattle.

Appearance.—All of these parasites are relatively small, hairlike worms about one-fourth to one-half of an inch long and of a brownish-red color when freshly collected.

The apparently marked difference in size between *Cooperia pectinata* and *C. oncophora*, as shown in figure 2, is due to the method of preservation for study. The live worms are approximately equal in size. The photograph of *Cooperia pectinata* was made from alcohol-fixed specimens and that of *C. oncophora* from formalin-fixed specimens.

Life history.—Very little is known about the life histories of these worms. The free-living larval stages are similar to those of related roundworms of cattle, but there is no information available as to their development in the host to the adult stage.

Distribution.—*Cooperia pectinata* appears to be confined to the Southern States. *C. oncophora* has a more northerly distribution. *C. punctata* has a wider distribution than either of the other two species, having been collected from both northern and southern parts of the United States.

Symptoms and lesions.—Very little is known as to the effect of these nematodes upon cattle, with the exception of *C. punctata*, which is definitely known to be pathogenic. This small nematode has been shown to burrow into the wall of the small intestine, especially the duodenum, and to cause marked lesions in the mucous lining. Profuse, watery diarrhea, anemia, rapid emaciation and death have been observed in calves heavily infested with this nematode. Deaths of calves due to infestation with *C. punctata* have been reported from Louisiana, Maryland, Virginia, and Ohio. Cases of parasitic enteritis due to *C. oncophora* have been reported from New York and Vermont.

Prevention.—Infestation of cattle with these parasites may be prevented by the procedures described under General Preventive Measures.

Treatment.—Although experimental evidence is lacking, repeated treatments with tetrachlorethylene as described for the medium stomach worm may be of value in the control of infestations with these worms. Phenothiazine when administered in the doses recommended for the removal of stomach worms, will remove only a small percentage of the cooperias present. It is, however, less effective against cooperias than against stomach worms.

The Thread-Necked Strongyles

Location.—The thread-necked strongyles, *Nematodirus spathiger* (fig. 2, *J*) and *N. helvetianus*, are found in the small intestines of cattle.

Appearance.—These are reddish worms. The anterior portion is more slender than the posterior, and the head and neck are thin and transversely striated. In *N. spathiger* the male is about ⅜ of an inch

and the female about 1 inch long. These two nematodes can be differentiated only by microscopic examination.

Life history.—The life history of these nematodes differs in some respects from that of the other nematodes mentioned. The rather large eggs pass out with the feces and an embryo develops in them. This embryo, instead of emerging from the shell and molting like the larvae of most other strongyles, molts twice within the shell. Under the influence of alternate moistening and drying or of temperatures varying from 75° to 90° F., the infective larvae emerge from the shells and crawl up on blades of grass like the larvae of stomach worms and thus enter the body of the host animal with the feed.

Distribution.—Available information regarding these nematodes in the United States, indicates that their distribution in cattle is largely confined to the central and northern parts of the country. In a fairly large number of cattle of different ages examined in Louisiana this nematode was found only once in a single animal, and in that case only one specimen was found.

Symptoms and lesions.—No symptoms and lesions have been definitely attributed to these worms in cattle. Reports of experiments with closely related species in sheep appear to show that these worms are not of any great pathologic importance, at least so far as sheep are concerned, except perhaps when present in very large numbers. Sheep harboring up to 6,500 adult worms in the small intestine showed no clinical symptoms which could be attributed to infestation with *Nematodirus*, although on post mortem examination minute hemorrhages were found in the mucous membrane of the small intestine at the sites where the worms were found. The effect of infestation with these worms on calves remains to be determined.

Treatment.—Tetrachlorethylene administered in repeated doses as directed for the medium stomach worm will probably control infestations with thread-necked strongyles.

Prevention.—Infestation of cattle with these strongyles may be prevented by following the control measures given under General Preventive Measures.

The Cattle Ascarid

Location.—The cattle ascarid, *Neoascaris vitulorum*, is sometimes found in the small intestine of calves.

Appearance.—This is a large whitish or yellowish worm from 6 to 12 inches long and almost as thick as an ordinary lead pencil.

Life history.—The life history of this worm is similar to that of the swine ascarid and differs from the life history of the strongyles in that the embryos develop and remain in the eggs. Infection occurs through ingestion of these embryonated eggs with feed or water which has been contaminated with the feces of infested animals. When the infective eggs are swallowed by a calf, they hatch in the small intestine. The larvae work their way into the small blood vessels and are carried to the liver and lungs. After completing a part of the life cycle in the lungs, they migrate up the trachea to the pharynx. They are then swallowed and grow to maturity in the small intestine.

Distribution.—The cattle ascarid is not known to be very common in the United States, but has been reported from Texas and Louisiana. It is much more common in other countries.

Symptoms and lesions.—In the course of their migration through the lungs the larvae of these worms, provided they are present in sufficient numbers, may cause a verminous pneumonia similar to that produced in pigs by the larvae of *Ascaris lumbricoides*. The adult cattle ascarid may cause unthriftiness and general digestive disturbances in affected calves.

Treatment.—Oil of chenopodium may be used for the treatment of ascarids in calves. The animals should be fasted for 24 hours before treatment and oil of chenopodium administered at a dose rate of 0.1 cubic centimeter for each kilogram (2.2 pounds) of body weight, immediately preceded or followed by at least 4 ounces of castor oil for young calves. Older calves should receive more castor oil. Oil of chenopodium should not be given to calves suffering from severe diarrhea, inflammation of the stomach or intestinal tract, chronic constipation, or febrile diseases, or to very weak and emaciated animals.

Prevention.—See discussion under General Preventive Measures.

PARASITES OF THE CECUM AND COLON

The Whipworm

Location.—The whipworm, *Trichuris ovis*, is usually found attached to the wall of the cecum or blind gut.

Appearance.—The body of this worm is made up of a thin front portion and a thick rear portion. The former may be compared to the lash of a whip and the rear part to the stock or handle (fig. 2, *B*), hence the name whipworm. The worms are white in color. The eggs of the whipworm are brown and are characteristically lemon shaped.

Life history.—So far as known, the whipworm has a simple life history. An infective embryo develops in the shell and cattle are infected by swallowing such eggs in grazing.

Distribution.—This worm has been collected from cattle principally in Louisiana, Texas, and Maryland but its distribution is probably Nation-wide.

Symptoms and lesions.—There are no well-defined clinical symptoms associated with whipworm infestation in cattle, but in man whipworm infestation sets up a low-grade inflammation with distinct symptoms of discomfort and distress. In camels a severe whipworm infestation has been found to cause a decided thickening of the wall of the gut with an excessive secretion of mucus and it is quite possible that in other animals heavily infested with whipworms similar pathological conditions may be produced. The front portion of the worm is usually found deeply buried in the mucosa lining the cecum and the most common lesions consist of inflamed and thickened areas surrounding the points of attachment.

Treatment.—No effective treatment is known for the removal of whipworms. Tetrachlorethylene will remove some worms but in heavy infestations this or any other known treatment would have to be repeated in order to control infestation. Directions for the use of tetrachlorethylene are given for the medium stomach worm.

Prevention.—Infestation of cattle with whipworms may be prevented by the application of the procedures discussed under General Preventive Measures.

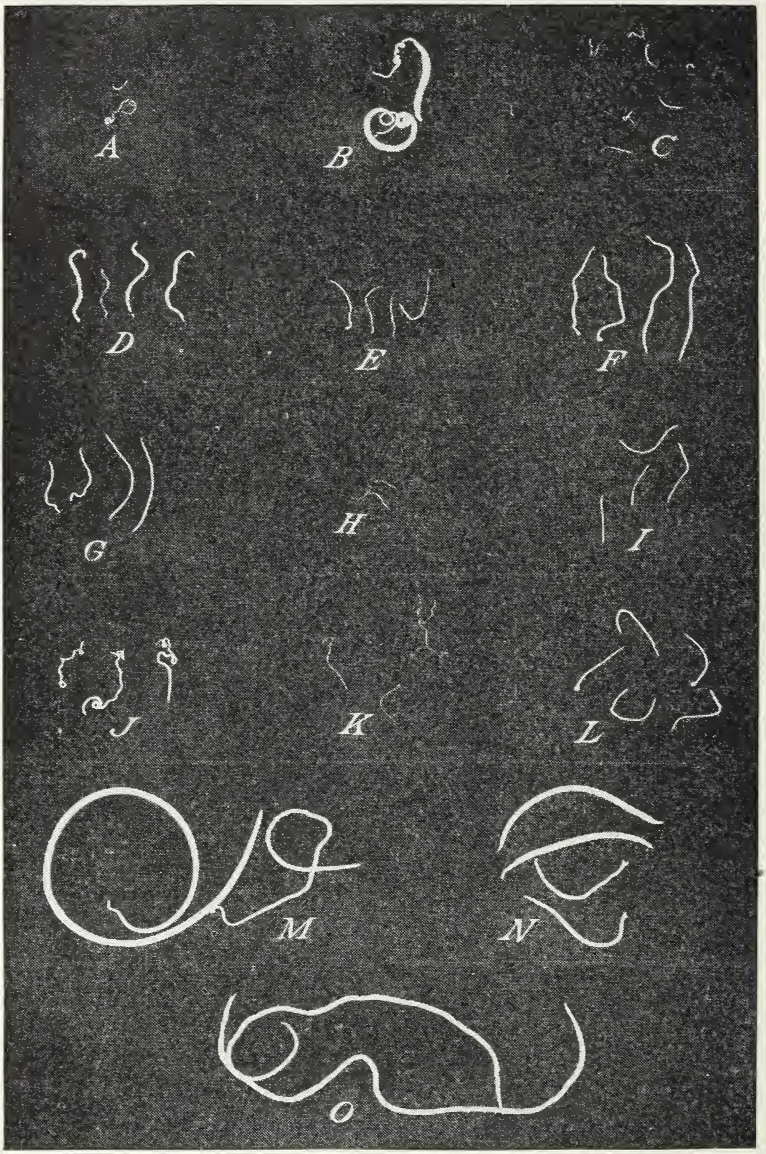

FIGURE 2.—Common roundworm parasites of cattle, natural size: *A*, *Stephanofilaria stilesi*; *B*, *Trichuris ovis*; *C*, *Trichostrongylus colubriformis*; *D*, *Oesophagostomum radiatum*: *E*, *Cooperia punctata*; *F*, *Haemonchus contortus*; *G*, *Haemonchus similis*; *H*, *Trichostrongylus axei*; *I*, *Ostertagia ostertagi*: *J*, *Nematodirus spathiger*; *K*, *Cooperia pectinata*; *L*, *Cooperia oncophora*; *M*, *Setaria labiatopapillosa*; *N*, *Bunostomum phlebotomum*; *O*, *Dictyocaulus viviparus*.

The Nodular Worm

Location.—The adult nodular worm, *Oesophagostomum radiatum*, (fig. 2, *D*), is found in the cecum and colon of cattle (fig. 3). The larvae are found in nodules in the large intestine and in the posterior part of the small intestine.

Appearance.—The nodular worm, *O. radiatum*, when full grown is a fairly large, white worm, about five-eighths of an inch long. The head is usually bent, forming a hook with the rest of the body.

Life history.—The free-living phase of the life history of this worm is similar to that of the other strongyles inhabiting the digestive tract of cattle. The eggs pass out with the manure, hatch, and the young worms develop into infective larvae in a few days. The larvae enter the body with the feed or water and make their way to

Figure 3.—Section of small intestine of a calf showing hemorrhagic nodules (dark spots) due to invasion of nodular worm, *Oesophagostomum radiatum*, larvae. (About natural size.)

the posterior part of the digestive tract. Although the complete life history of this particular worm has not been worked out experimentally in cattle, it is probably similar to that of *O. columbianum*, the nodular worm of sheep. In the case of *O. columbianum* the larvae, after reaching the cecum, penetrate into the wall of this organ and encyst there causing typical nodules. Approximately 8 days later, the larvae, which have grown considerably in the meantime, leave the cysts and nodules and attach themselves to the wall of the intestine. The infective larvae develop into the adult stage about 40 days after being swallowed.

Distribution.—The nodular worm of cattle has a wide distribution. The Bureau of Animal Industry helminthological collection contains specimens from Texas, Louisiana, Florida, Tennessee, North Carolina, Virginia, Maryland, Illinois, Iowa, Missouri, Colorado, and British Columbia.

Symptoms and lesions.—The symptoms caused by this parasite are similar to those caused by other roundworm parasites of cattle.

During the invasion of the wall of the intestine the animal may suffer from severe diarrhea and emaciation. The lesions consist of hemorrhagic nodules in the wall of the intestine.

Treatment.—Phenothiazine has been found to be effective in treating cattle for the removal of nodular worms. For dosage see those recommended for the twisted stomach worm.

Prevention.—Infestation of cattle with nodular worms may be prevented by following the procedures mentioned under General Preventive Measures.

PARASITES OF THE RESPIRATORY SYSTEM

The Lungworm

Location.—The lungworm, *Dictyocaulus viviparus* (fig. 2, *O*), is found in the trachea and bronchi of cattle, especially of calves.

Appearance.—The lungworms are white, threadlike worms from 2 to 4 inches long.

Life history.—The life history of the lungworm is similar to that of the other strongyles of cattle in its preparasitic and free-living stages. The eggs deposited by the female hatch in the lung of the host animal and the larvae are expelled in coughing, or they are swallowed and passed in the feces. After reaching the outside, the larvae molt twice and under favorable conditions of temperature and moisture reach the infective stage in the course of a few days. When the weather is warm and sufficient moisture is present, the larvae climb up on grass blades and are swallowed by animals in grazing. Although the parasitic stages of this particular nematode have not been worked out experimentally, it is reasonable to believe that they are similar to those of *Dictyocaulus filaria*, the lungworm of sheep. In the case of *D. filaria* the infective larvae, after reaching the small intestine, pass into the lymph stream and through the lymph stream into the lungs by way of the heart. In the lungs they develop into adult worms.

Distribution.—The lungworm of cattle has a Nation-wide distribution.

Symptoms and lesions.—The worms, their eggs, and their larvae set up an irritation in the bronchi at the point where they are located, causing an inflammation and catarrhal condition, the latter manifested in the production of a frothy mucus, sometimes containing traces of blood. This irritation results in the production of a husky cough which is usually the first symptom noted. Severe infestations cause difficulty in breathing, discharge from the nose, general unthriftiness manifested by a roughened hair coat, and loss of weight. There is usually a diarrhea. The disease may be diagnosed from the clinical symptoms by an experienced veterinarian or stockman who is familiar with it.

Post mortem examination of an animal dead from lungworm disease reveals the worms in the bronchi and the condition of a verminous bronchitis and pneumonia.

Treatment.—There is no effective medicinal treatment for the removal of lungworms in calves. Many drugs have been recommended for administration by inhalation or injection into the trachea or windpipe, but it has not been shown that such drugs actually kill

the lungworms. On the other hand, such drugs when so used, may be responsible for considerable irritation and inflammation of the delicate lining of the trachea and bronchi and may even produce pneumonia. In experimental work with such treatments, untreated control animals showed greater improvement than did the treated animals. The present evidence indicates that the best method of dealing with lungworm infestation in calves is to remove the animals from lots or pastures contaminated with parasite eggs and larvae, to provide adequate shelter, a nourishing ration, and to supply drinking water which has not been contaminated with pasture or barnyard drainage. The addition to the ration, of salt and other minerals, such as steamed bonemeal, is indicated.

Prevention.—In areas where lungworms are prevalent calves should not be permitted to graze with older animals or be kept on infected pastures. They should be raised in the barn or in dry lots at least for the first 6 months of their lives. They should be well fed and cared for in order that they may make the maximum growth in that period.

The Throat Worm

Location.—This parasite, *Syngamus laryngeus*, is found in the upper part of trachea or windpipe of cattle.

Appearance.—Throat worms are fairly thick worms about ½ of an inch to 1 inch long and blood red in color when freshly collected. The females are attached to the wall of the trachea and the males are usually attached to the females, which gives the worms the appearance of being forked.

Life history.—The life history of the throat worm is not definitely known but is probably similar to that of *S. trachea*, the gapeworm of chickens. In the case of the chicken gapeworm the eggs pass out of the host with the droppings and develop to infective larvae within the shell. Some of these infective larvae emerge from the shell; others do not. When such eggs or infective larvae are swallowed, they ultimately reach the trachea where they develop into adult worms.

Distribution.—The throat worm has been found in Puerto Rico, Asia (India, Dutch East Indies, Philippine Islands), and South America (Brazil, Uruguay).

Symptoms and lesions.—No particular lesions have been reported for these worms in cattle other than a local tissue reaction at the point of attachment. Frequent coughing has been reported in an animal in which the worms were found attached in the pharynx.

Treatment.—There is no effective treatment for this infection.

Prevention.—Infestation of cattle with throat worms may be avoided to a large extent by following the procedures discussed under General Preventive Measures.

ROUNDWORMS OF THE ABDOMINAL CAVITY

Location.—These worms, *Setaria labiato-papillosa* (fig. 2, *M*), are frequently found free in the abdominal cavity of cattle. They are occasionally found embedded in, or attached to, organs and tissues within the abdominal cavity.

Appearance.—The worms are threadlike, 2 to 4 inches long, and white in color.

Life history.—The embryos produced by these worms are found in the blood stream as sheathed microfilariae. They are probably transmitted from animal to animal by some blood-sucking insect.

Distribution.—The worms have a wide geographical distribution, occurring in cattle in all parts of the United States.

Symptoms and lesions.—Neither clinical symptoms nor pathological lesions have been attributed to the presence of these nematodes.

Treatment.—No medicinal treatment has been developed for the destruction of these worms.

Prevention.—Since the life history of these nematodes has not been worked out and the intermediate host is not definitely known, no preventive measures can be recommended.

ROUNDWORMS OF THE SKIN

Location.—These roundworms, *Stephanofilaria stilesi* (fig. 2, *A*), are located in the lesions found along the midline on the abdominal surface of cattle. These parasites spend most of their life cycle in the skin and are therefore considered internal parasites.

Appearance.—The worms are small, about one-eighth to one-fourth of an inch long and white in color.

Life history.—The life history of these worms has not been worked out. The unsheathed microfilariae are found in the lesions, together with the adults. Since all the members of the group to which these worms belong require an intermediate host in their life cycles, it is assumed that some insect acts as intermediate host, and serves to transmit the infection from animal to animal.

Distribution.—Lesions attributable to *Stephanofilaria* have been found on cattle from many of the Western and Southern States and the worms, therefore, appear to have a wide geographical distribution in the United States.

Symptoms.—No particular clinical symptoms have been attributed to infestation with these nematodes.

Lesions.—The lesions consist for the most part of thickened, hairless and partially hairless patches of skin found on the ventral surface of the body in and adjacent to the midline, either anterior or posterior to the navel. Lesions have been found also in the groin, on the anterior surface and tip of the scrotum, and on the escutcheon.

The lesions vary considerably in size ranging from less than 1 inch to about 6 inches in diameter. They differ also greatly in appearance, some of them appearing as small areas, from one-fourth to one-half of an inch in diameter, not altogether hairless but marked with spots of dried blood and serum. Other lesions appear as areas about 1 inch in diameter, hairless, and moist with blood and serum. This blood and serum may be dried, forming scabs and crusts. Judging from clinical appearance, such areas may heal without spreading, in which case an area of smooth, hairless, and thickened skin is observed. One animal showed a number of such apparently healed lesions extending for a distance of about 15 to 18 inches along the midline both in front of and back of the navel. In other cases the initial lesion apparently extends peripherally, in which case an area about 2 to 3 inches in diameter, with a hairless, wrinkled, and thickened

center and the edges marked with numerous small hemorrhagic spots, may be observed. In still other cases the area involved, which may be several inches in diameter, appears grayish and is covered with a heavy dry crust marked with cracks and crevices. In some cases this crust, instead of being dry and grayish in appearance, is deep red in color and the cracks appear moist and bloody. Most of the lesions have been observed in mature animals of both sexes, but fairly extensive lesions have also been noted in animals 2 years old and younger.

The disease can be diagnosed with reasonable certainty on the basis of the location and gross appearance of the lesions. Such presumptive diagnosis can be confirmed by finding adult nematodes, pieces of adult nematodes, or larvae either free or enclosed in a vitelline membrane, in scrapings made from the lesions. For the purpose of skin scrapings active lesions only should be selected, an active lesion being interpreted as a lesion showing exudation of blood and serum either moist or dried in the form of scabs or crusts. All scabs must be removed from the area prior to scraping and scrapings must be deep enough to draw blood.

Treatment.—No treatment of this condition has been developed.

Prevention.—Until the life history of this nematode has been determined and the identity of the intermediate host has been ascertained, no suggestions as to possible preventive measures can be given.

ROUNDWORMS OF THE EYE

Small roundworms, about one-third to four-fifths of an inch in length, may occur in the ducts of the tear glands, between the eye and the lids, or under the nictitating membrane of the several species, all belonging to the genus *Thelazia*. One species, *T. rhodesi*, has been reported as occurring in the eyes of cattle in California.

Location.—The worms, *Thelazia rhodesi*, normally occur in the ducts of the tear glands but they may escape from their usual location and be found on the surface of the eyeball beneath the lids, under the nictitating membrane or even in the eyeball.

Appearance.—These worms are white in color, slender, and attenuated at both ends. The males are from ⅓ to ½ of an inch, and the females from ½ of an inch to 1 inch long.

Life history.—The life cycle of this parasite is unknown. Probably it has intermediate stages in some arthropod.

Distribution.—Up to the present time this worm has been reported only from cattle in California.

Symptoms and lesions.—According to Griffiths, the first symptoms noted are profuse lacrimation, photophobia and cloudiness of the cornea, to be followed later by definite opacity of the cornea. As a result of the invasion by pus-producing organisms the cornea may become ulcerated and this, in turn, may lead to an inflammation of the iris and other structures of the eye. If the worms are not removed, the eyelids and the nictitating membrane may become swollen and, owing to the drying of the purulent discharge exuding between the eyelids, the lids become adhered. The globe of the eye becomes more and more involved and is finally destroyed.

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Mechanical injuries due to loss of sight and the fixation of the nictitating membrane, which is unable to function because of its swollen condition, may aggravate the primary condition.

Diagnosis.—The presence of these eyeworms may be suspected when one or more animals in a herd show indications of sensitivity to light with profuse lacrimation. The parasites are most easily found in animals showing the earliest stages of the clinical manifestations, namely, lacrimation with slight opacity of the cornea and little, if any, purulent discharge. The septic processes due to secondary infection appear to kill off the nematodes, or at least, to confine them to the depths of the lacrimal ducts. The worms are not always seen in a cursory examination of the eye, because of their unusual habitat. It is necessary, therefore, to examine the parts thoroughly by exposing the under surface of the nictitating membrane and the eyelids when the worms can be detected by their active wriggling movements in the lacrimal secretion. They appear to be washed up with the tears from the lacrimal duct, as any manipulation or application of dressing which tends to increase the lacrimal secretions facilitates the recovery of specimens from infected animals.

Prevention.—Until the life history of these worms has been worked out no preventive or control measures can be recommended.

Treatment.—The treatment consists in the mechanical removal of the worms from the eye. After the worms have been removed the eyes should be treated as in cases of inflammation due to other causes.

TAPEWORMS OF CATTLE

Cattle in the United States may harbor both adult and larval tapeworms. The adult tapeworms have a head provided with four suckers and a body consisting of a number of flat segments joined together to form a chain. They produce eggs of microscopic size which pass out in the manure together with gravid segments and which on being ingested by a suitable host develop into an intermediate stage or larva. Cattle become infested by swallowing such larvae.

The larval tapeworms which occur in cattle are commonly known as bladder worms; they are usually located in the tissues or cavities of the body. These bladder worms usually consist of a head and neck inverted in a membrane containing a clear fluid. When bladder worms are eaten by the final host, the heads of the tapeworms become extruded and pass to the small intestine where they grow into adult worms by the proliferation, or development of segments, back of the head.

The Moniezias

Location.—Two species of tapeworms, *Moniezia expansa* and *M. benedeni*, are known to occur in the small intestine of cattle in the United States.

Appearance.—These tapeworms are long, flat, ribbonlike worms, which sometimes attain a length of several yards and a breadth of three-fourths of an inch.

Life history.—It has been reported that the eggs of these tapeworms will develop into tapeworm larvae or cysticercoids when ingested by certain free-living mites, known as beetle mites (fig. 4). Details

concerning the life history of these mites, their occurrence on pastures, conditions which favor their development, persistence, and the time required for the development of the tapeworm eggs to the cysticercoid stage, are not yet available.

Distribution.—The tapeworms of cattle are cosmopolitan in their distribution.

Symptoms and lesions.—The symptoms of tapeworm infestation appear to be similar to those of other worm infestations. (See

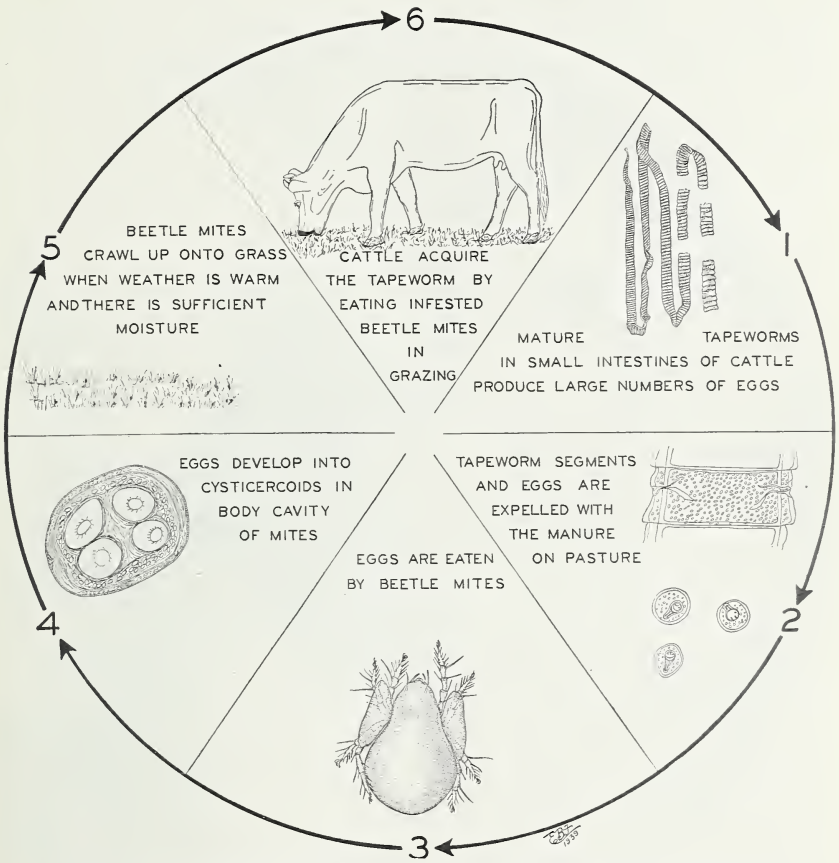

Figure 4.—Life cycle of *Moniezia expansa*, the common tapeworm.

General Symptoms of Worm Infestations.) No definite lesions have been attributed to these parasites.

Treatment.—The copper sulfate and nicotine sulfate solution used for the removal of the common stomach worm is partially effective for the removal of tapeworms from sheep. Its value for cattle has not been ascertained, but its use is warranted on theoretical grounds.

Prevention.—No recommendations as to prevention can be given until detailed information on the life history of the intermediate host has been obtained.

BLADDER WORMS

The Thin-necked Bladder Worm

Location.—The thin-necked bladder worm, *Cysticercus tenuicollis*, is found in the abdominal cavity attached to the mesenteries, omenta, or in the liver.

Appearance.—This bladder worm has the appearance of a sac filled with clear fluid; a white object, which is the head and neck,

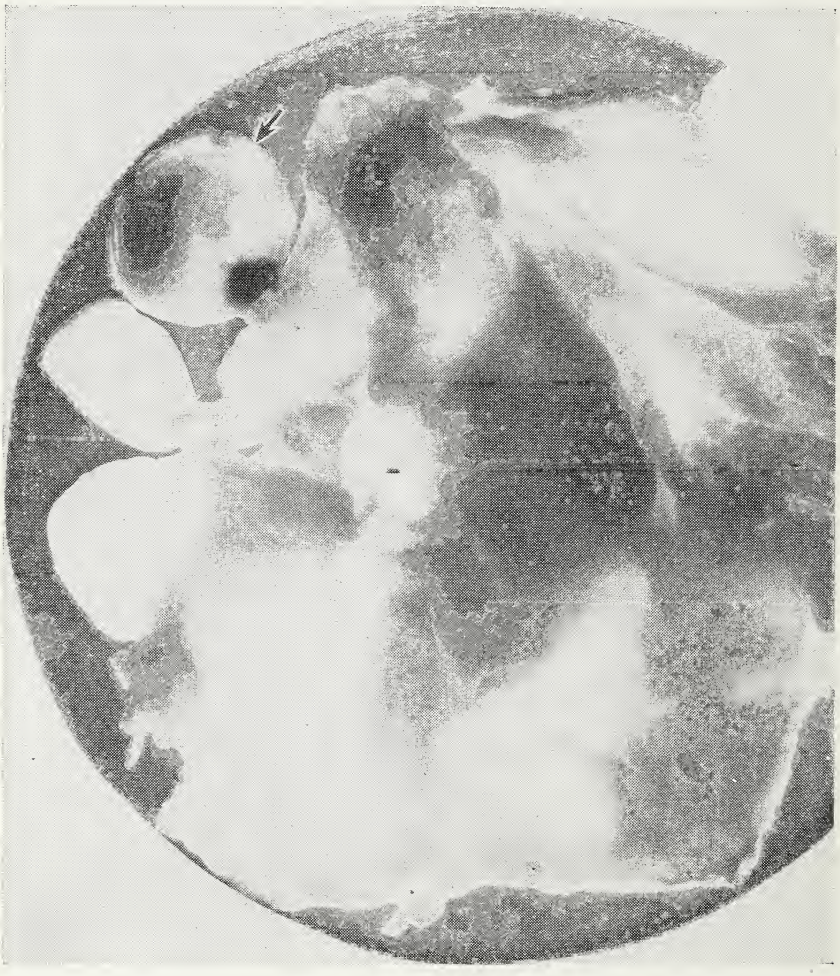

Figure 5.—Bladder worm, *Cysticercus tenuicollis*, shown by arrow in the membrane of the abdominal cavity.

projects into the bladder from one end (fig. 5). The bladder is usually about 1 inch in diameter, but may attain a length of several inches. The bladder worm proper is surrounded by a cyst wall, which is developed by the host animal as a protective measure against the parasite. When this cyst is broken, the parasite usually rolls out and is seen to be a thin-walled structure. By appropriate laboratory

treatment the head and neck of the parasite may be everted and made to protrude from one end of the bladder.

Life History.—If one of these bladder worms is ingested by a dog, the cyst wall is digested and the tapeworm head and neck, passing into the small intestine, develop into a mature tapeworm (*Taenia hydatigena*) by development of segments back of the neck. Egg-bearing segments develop in from 10 to 12 weeks. When dogs and related carnivores infested with these tapeworms run over pastures used by cattle they may leave feces containing tapeworm eggs and segments on the pasture. These eggs may be spread by rain onto the grass and into streams and puddles from which the animals drink. When cattle ingest these eggs with feed and water the embryo escapes from its shell, makes its way to the liver, and begins to develop. In the course of time it escapes from the liver and becomes attached to the mesenteries or omenta. At first it is a bladder without a head, but later a head and neck develop, and the full formed cysticercus is then ready to infect any susceptible dog that eats it.

Distribution.—This parasite is generally distributed over the United States. It is most likely to be present where cattle are associated with dogs or where stray dogs commonly run over pastures, and where animals are slaughtered on farms or at small country slaughterhouses at which little care is exercised in disposing of the viscera and of diseased portions of the carcasses.

Symptoms.—Light infestations with these bladder worms or tapeworm larvae produce very little damage. Severe infestations may make an animal very sick and may even cause death. In such cases the animals show symptoms of dullness, weakness, loss of appetite, and fever. These symptoms are due to hemorrhage from the liver and peritonitis which is caused by the wandering of the larvae in the liver. The symptoms appearing in the early stages of the infestation are seldom associated with invasion of tapeworm larvae.

Lesions.—On post mortem examination the bladder worms may be found in the liver or in the abdominal cavity attached to the mesenteries or omenta. No particular lesions are associated with light infestations. In animals dying of hemorrhage from the liver and peritonitis resulting from massive invasion of the liver by the larval tapeworms, the liver surface shows superficially a series of short ridges or serpentine markings running in all directions; these markings are most numerous near the thin edge of the liver. On cut sections the liver substance shows many burrows caused by the wandering tapeworm larvae.

Treatment.—There is no effective treatment for bladder worm infestation of cattle.

Prevention.—Dogs should be prevented from eating parasitized meat and viscera. Slaughterhouse refuse should not be left where dogs can have access to it.

Dogs should be kept free from tapeworms. As a routine measure, dogs that have access to infective material should be treated for tapeworm infestation about four times a year.[1] Stray dogs and other carnivores may be kept out of pastures by fencing or other measures.

[1] For further details concerning the tapeworms of dogs see U. S. Department of Agriculture Department Circular 338, Parasites and Parasitic Diseases of Dogs.

Beef Measles

A condition known as beef measles is caused by *Cysticercus bovis* (fig. 6), the larval form of the tapeworm, *Taenia saginata*, of man.

Location.—The parasite is usually found in the voluntary muscles and heart of infected cattle, but may occur in the lymphatic glands, lungs, liver, and other organs.

Appearance.—These parasites occur as small spherical to elliptical bladder worms, one-fifth to three-fifths of an inch long and from one-

Figure 6.—A piece of muscle from a cow infected with beef measles, *Cysticercus bovis*. Note small white embryos, indicated by arrows.

eighth to one-third of an inch wide. They are whitish to gray in color, with a small yellowish spot which is the invaginated head or scolex. The bladder consists of a thin wall and contains but little liquid. Calcareous corpuscles occur in both the bladder and scolex. The head or scolex is unarmed (free of hooks).

Life history.—The eggs produced by the adult tapeworm in man are passed with the feces. Eggs passed on pastures, around barn-

yards, feed lots, wherever cattle are grazing or being fed may be ingested by them. On reaching the digestive tract the eggshell is digested and a six-hooked embryo is released. This embryo is carried by the blood stream to the heart and then to the muscles where it usually locates. The embryo loses its hooks and in from 7 to 18 weeks develops into a mature bladder worm. When live bladder worms are ingested by man the bladder and the surrounding cyst wall are digested and the undigested scolex passes to the intestine where it grows into the adult tapeworm, *Taenia saginata*.

Distribution.—This bladder worm has been found, in the course of Federal meat inspection, in cattle in abattoirs in the United States. The parasite occurs in about 0.4 percent of all cattle slaughtered.

Symptoms.—Mild infestation with cysticerci produces no appreciable effect on the host animal, but severe infestations may produce distinct symptoms. Cases of artificially produced infestation have shown symptoms of fever, accelerated pulse, difficult breathing, diarrhea, swollen abdomen and a stiff gait, the condition terminating in death in about 23 days. However, it is doubtful whether under ordinary circumstances such symptoms would be attributed to cysticercosis.

Lesions.—As a rule there are no marked lesions associated with cysticercosis, that is, no marked injury is noted in the tissues invaded by the parasites. In cases of fatal artificial infestation, post mortem examination shows a reddish serous exudate in the body cavities, edema of the subdermal connective tissues and dark-red musculature with thousands of tuberclelike cysticerci in the heart and elsewhere in the carcass.

Treatment.—There is no treatment for this condition.

Prevention.—Since cattle become infested by ingesting the eggs of the tapeworm passed in human feces, it is obvious that the best method of preventing such infestation lies in the proper disposal of human feces. A person infested with the tapeworm *Taenia saginata*, by defecating around the barn, the cattle yards, and on pastures, may cause a large number of animals to become infested with larval tapeworms. It is also necessary in feeding and watering cattle to take into consideration the presence of sewers and discharges of sewage since cases of cysticercosis in cattle have been definitely traced to pastures irrigated with sewage.

The Hydatid

Location.—Hydatids or echinococci are the bladder worms of *Echinococcus granulosus*, a tapeworm found in dogs and related carnivores. In cattle hydatids occur most frequently in the liver and lungs, but they may occur in practically any organ or tissue.

Appearance.—Hydatids in cattle appear in the form of cysts (fig. 7), usually in the liver and lungs and less frequently in other organs. The cysts may vary from less than ¼ of an inch to more than 6 inches in diameter. They may be single or multiple.

One form, which is found in the livers of cattle, is known as *E. multilocularis*. According to Monnig, it consists of a conglomeration or mass of small sterile bladders, each about 1 centimeter (⅖ of an inch) in diameter, separated from one another by fibrous tissue. This form resembles the *E. alveolaris* found in man, but differs from it in some essential features. *E. alveolaris* consists of a fibrous stroma

containing numerous small bladders, of which some may be fertile. It is not definitely separated from the host tissue and grows like a tumor, infiltrating the liver tissue. It may invade the blood vessels and by metastasis give rise to hydatids or echinococcus cysts in other organs. The sterile cysts contain fluid only, the fertile cysts contain minute objects resembling grains of sand attached to the cyst wall or lying unattached in the fluid. These grains are brood capsules and each one may contain a number of very small tapeworm heads. The

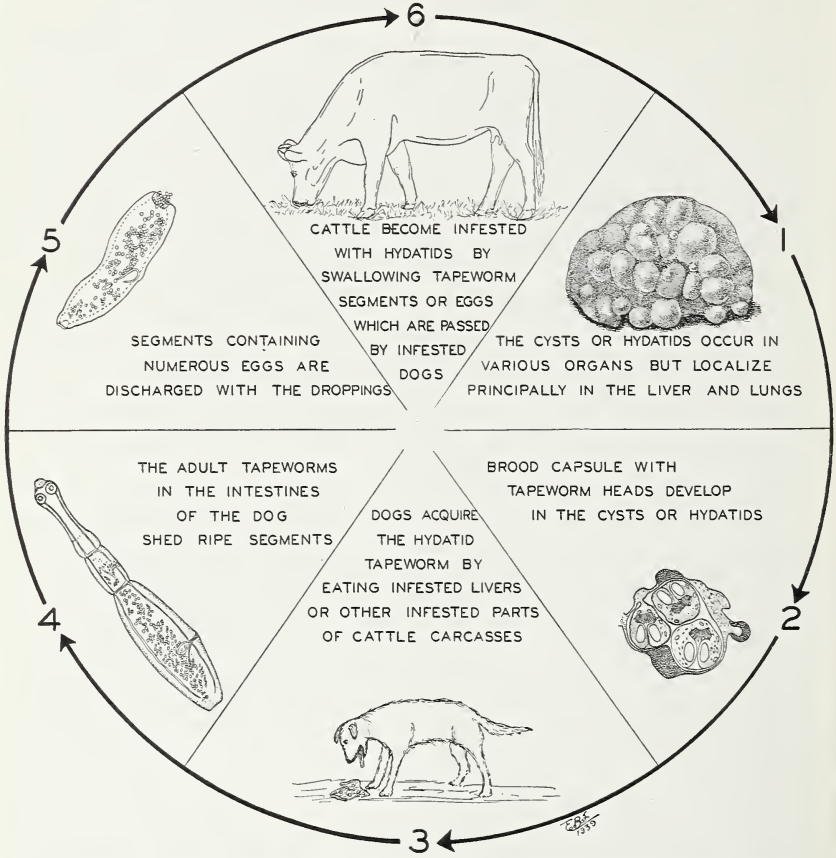

FIGURE 7.—Life cycle of the hydatid tapeworm, *Echinococcus granulosus*.

multilocular type of cyst presents a honeycomb appearance when cut. The other form is known as the unilocular type.

LIFE HISTORY.—When fertile cysts containing brood capsules are eaten by a dog, cat, or other suitable host animal, each tapeworm head may develop into a strobilate tapeworm. As the hydatid cyst may contain thousands of such heads the host animal may become infested with large numbers of these worms. These tapeworms are only about one-fifth of an inch long and consist of a head with three to five segments. The eggs and gravid segments produced by the tapeworm in the intestine of the dog or of other hosts pass out in the feces and are ingested by cattle in grazing. After ingestion the egg

hatches, releasing an embryo which makes its way to the liver or some other suitable tissue or organ and develops into a hydatid.

Distribution.—Although this tapeworm of dogs and related carnivores has a world-wide distribution, there is very little definite information on the frequency of its occurrence and its geographical distribution in the United States. Meat-inspection records covering the last decade indicate that approximately 1,200 cattle livers were condemned each year for hydatid infestation. The location of the establishments at which these livers were condemned indicates a wide distribution of the parasite throughout the United States.

Symptoms.—The symptoms shown by animals affected with hydatids depend upon the location of the parasite and its size. If the parasite is small or does not crowd important organs, few or no symptoms will be manifested. When the parasite is located in the heart or brain or in another vital organ, there may be marked symptoms or even death from pressure or rupture of the cyst. As a rule, infestations are not detected or diagnosed during life, but are found only on post mortem examination.

Lesions.—In the unilocular type of cyst formation in which the hydatid is enclosed in a connective-tissue capsule the lesions are those of a pressure atrophy and the extent of the lesion will depend upon the size and location of the cyst. The multilocular type of cyst may spread through the parasitized host organ by infiltration and become neoplastic and ulcerative.

Treatment.—The only treatment for this condition is surgical, but this is not feasible in cattle even if the condition could be diagnosed.

Prevention.—The most important preventive measure is the proper disposal of carcasses and portions of carcasses of animals dying on the farm or killed on the farm or elsewhere. If diseased viscera, such as livers infested with hydatids, are thrown out where dogs can get at them, the parasites will continue to propagate.

FLUKES OF CATTLE

Cattle in the United States may be infested with one or more species of flukes. Two kinds of flukes, which are flat, leaflike parasites may occur in the liver, and two other kinds are commonly found in the rumen or paunch. Flukes reproduce by means of eggs which pass out with the manure. These eggs hatch in water, releasing ciliated embryos known as miracidia. The miracidia enter the bodies of certain species of snails and develop into cercariae, which encyst on vegetation. Encysted cercariae are ingested by cattle in grazing and develop into mature flukes.

The Common Liver Fluke

Location.—The common liver fluke, *Fasciola hepatica*, is found in the liver, bile ducts, and gall bladder of cattle. In heavy infestations it has also been found in abscesses in the lungs.

Appearance.—The common liver fluke is a flattened, leaflike, brown worm usually about an inch long. There is a sucker at the anterior, or front end, on a cone-shaped extension, and just behind this is a ventral sucker. The branching intestine and the uterus

filled with eggs can be seen through the skin or cuticula covering the parasite.

Life history.—The eggs produced by the adult flukes of the species *Fasciola hepatica* pass out in the feces and hatch in water, releasing a ciliated embryo, known as the miracidium (fig. 8). This embryo attacks and bores into certain species of snails. Within the snail it undergoes certain changes which in time give rise to a form known as the cercaria. This cercaria resembles a small fluke provided

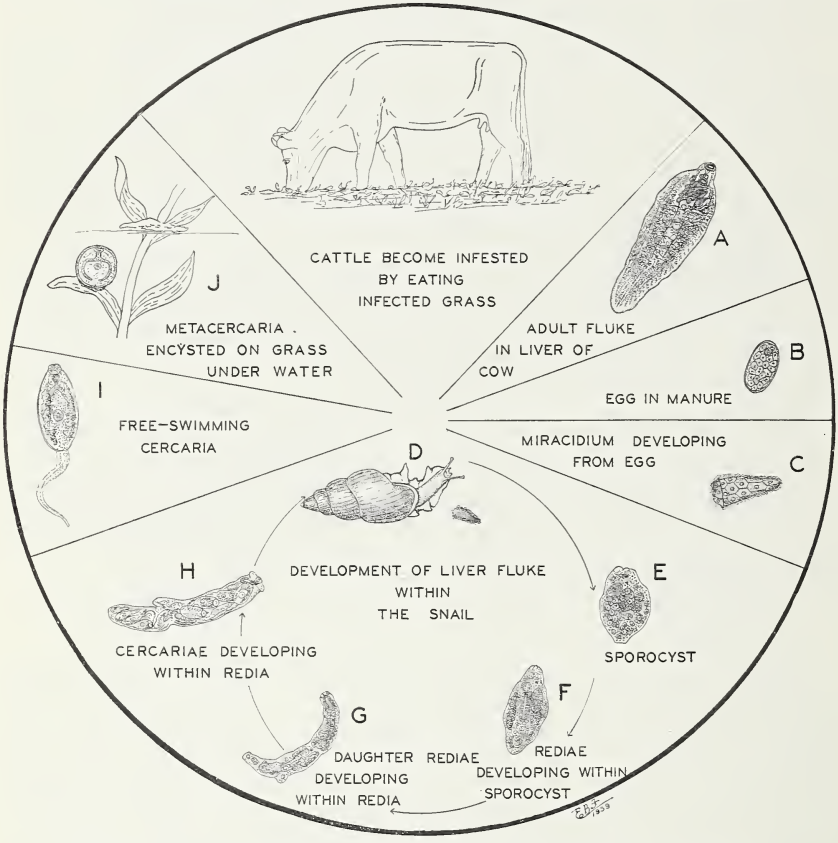

Figure 8.—Life cycle of the common liver fluke, *Fasciola hepatica.*

with a tail by means of which it swims about. It finally loses its tail and encysts. The encysted cercariae may float about on water or they may attach themselves to grass blades or other vegetation. When swallowed by cattle or other suitable host animals, the larval flukes, on reaching the small intestine, bore through the wall to the body cavity. Here they wander over the surface of the viscera and walls of the body cavity, finally perforating the capsule of the liver and reaching the extremities of the biliary ducts. In the liver the young flukes grow to maturity in the larger bile ducts.

Distribution.—The distribution of the common liver fluke is world-wide; wherever low, wet pastures and suitable intermediate

snail hosts occur. In the United States it is most prevalent in the Pacific Coast States, in the Rocky Mountain States, in the Southwest, and Southeast.

Symptoms and lesions.—The symptoms associated with liver-fluke infestation are similar to those of general worm infestation; that is, unthriftiness and anemia. Calves may be killed by heavy infestations with the common liver fluke. The lesions caused by the common liver fluke include production of large areas of scar tissue in the liver and the enormous thickening of the bile ducts on the undersurface of the liver. This thickening of the bile ducts is very pronounced in older animals. There is also calcification of the bile ducts in cattle, and this lesion is permanent.

Treatment.—Carbon tetrachloride is an effective treatment for the destruction of liver flukes in cattle. However, the drug is not well tolerated by cattle, particularly milking animals, and severe reactions and some deaths are frequently associated with the administration of the drug. The therapeutic dose of carbon tetrachloride is from 5 to 10 cubic centimeters (about 1 to 2.5 drams) administered in hard gelatin capsules or by stomach tube. Yearling cattle may be given a dose of 5 cubic centimeters while adult cattle of average weight may be given 10 cubic centimeters of the drug. In small, weak animals, it is advisable to divide the dose, giving 2 cubic centimeters and 3 cubic centimeters (0.5 to 0.75 dram) on consecutive days. Cattle approaching 2 years of age may be given 7 to 10 cubic centimeters (1.75 to 2.5 drams). It is believed that milking animals react unfavorably to carbon tetrachloride because of a low level of blood calcium. For this reason it is advisable to add steamed bonemeal to the ration at the rate of 4 ounces for each animal per day for 2 to 3 weeks before and for 4 days to 1 week after the administration of carbon tetrachloride. If there are symptoms of carbon tetrachloride poisoning, such as muscular tremors, diarrhea, low-grade fever, prostration, and convulsions, calcium gluconate, or other calcium salts suitable for intravenous use, should be given. Experience indicates that even with these precautions, severe reactions and deaths sometimes occur.

Experimental evidence indicates that carbon trichloride, or hexachlorethane, is an effective remedy for the destruction of flukes in cattle, and is apparently much safer than carbon tetrachloride. Hexachlorethane may be given to adult cattle in a dose of 10 grams (2.5 drams) in capsule for each 25 kilograms of body weight (1 kilogram equals 2.2 pounds). This dose is distributed over 4 consecutive days. Hexachlorethane should be combined with an equal quantity of sugar to prevent balling of the drug in the intestinal tract.

Prevention and control.[2]—The destruction of the snails which are the hosts of the intermediate stages of the fluke is the most important control measure for flukes of sheep and cattle. This may be accomplished by draining wet areas where snails propagate and using copper sulfate for the destruction of snails or by a combination of the two procedures. Since snails require a certain quantity of water in which to live and propagate, drainage is the preferred method because complete drainage will remove the water from the infested areas and so change the environment as to make it impossible for snails to survive in these areas. If the drainage ditches are kept open and all standing

[2] For details, see "Control of liver flukes and fluke disease of sheep, goats, and cattle," by Robert Jay, a mimeographed circular of the Bureau of Animal Industry, U. S. Department of Agriculture.

water is removed, the drained area will remain unfavorable for snails and will require no other attention. If the ditches become infested with snails the banks may be treated with copper sulfate and the snails destroyed. Although drainage is the method to be preferred, it cannot always be used because of either the cost of establishing drainage or because of engineering difficulties. In figuring the cost of any drainage project, however, the increased value of the land and the improved forage that may be produced on such land should always be considered. Wherever drainage is either impracticable or impossible the treatment of snail-infested areas with copper sulfate should be considered.

Copper sulfate, also known as bluestone and blue vitriol, has proved to be very effective for killing snails. Although this chemical will kill snails overnight in a dilution of 1 part to 1,500,000 parts of water, the thorough distribution of such small quantities is difficult to accomplish, and it is usually applied in much greater concentration.

The method of application varies with the movement and distribution of the infested waters. In a stream originating on a stockman's land and with the water confined within definite banks, sacks containing large crystals of copper sulfate may be placed in the head waters. To reach the snails on the banks, dams may be thrown across the stream at various places, depending upon the fall of the stream, to raise the treated water to cover the snails. Overflow lands, stagnant back waters, marshes, pools, and similar wet places are best treated by broadcasting powdered copper sulfate. Do not overlook the water troughs, especially the puddles around the troughs. It is more economical to use the powdered copper sulfate for treating these places. The chemical may be mixed with sand as a carrier in the proportion of 1 part of the copper sulfate to 4 to 8 parts of sand, depending upon the volume of water to be treated.

The quantity of copper sulfate to be used can be estimated by finding the number of cubic feet of water to be treated and reducing the cubic feet to pounds by multiplying by 62.5, the number of pounds in a cubic foot of water. An acre of water 1 foot deep contains 43,560 cubic feet, or so-called acre-feet. For a dilution of 1 part of copper sulfate to 500,000 parts of water there would be required about 5½ pounds. To use this small quantity it would be necessary to reduce the sulfate to a dust and mix with a carrier to obtain uniform distribution. Much larger quantities can be used without endangering livestock and with very slight increase in cost. The airplane has been found to be practical in spreading copper sulfate over large swampy areas, but when applied in this way the copper sulfate and sand mixture must be fine enough to apply as a dust.

Copper sulfate kills the snails, the miracidia, and the free-swimming cercariae. It does not injure the fluke eggs or the encysted cercariae; therefore, to prevent infestation, the snails should be destroyed before the water and grasses become infected which usually occurs in the spring or early summer.

Copper sulfate, as used in dilutions for killing snails, is not injurious to grasses and flowering plants, and will not poison livestock. It will kill the lower forms of plant life, such as the algae and mosses, and may kill fish.

To estimate the quantity of copper sulfate needed to treat the water in a stream, it is necessary to know the flow in cubic feet per second.

To obtain this, select a uniform section of the stream about 50 feet long, and measure the width and average depth of the flowing water to get the area of cross section in square feet. Mark off 50 feet, throw a chip in the water, and ascertain the time required for the chip to float 50 feet. This will be the velocity in feet per second. The number of square feet of cross section multiplied by the velocity in feet per second equals the approximate flow in cubic feet per second. For example: A stream 6 feet wide has an average depth of 6 inches; the area of cross section equals 6 times 0.5, or 3 square feet. If it takes a chip 25 seconds to float 50 feet, the rate of flow is 2 feet per second. Multiply the cross section (3 square feet) by the velocity (2 feet per second) and the result is a flow of 6 cubic feet per second. For a 24-hour treatment at a dilution of 1 to 500,000 parts of water, 11 pounds of copper sulfate are required for each cubic foot per second of flow. Therefore, the amount of copper sulfate required for a stream of this sort would be 6 times 11 pounds, or 66 pounds of copper sulfate.

If the quantity of copper sulfate required to treat the water in a lake would be excessive or if the lake is used as a fish preserve, the copper sulfate may be broadcast along the banks and on the water a few feet out from the bank.

A few days after the treatment of the water, it is well to make a careful investigation of the effect of the treatment on the snails. Usually one treatment at the right time is enough for that year, but if live snails are found after an application of copper sulfate, the waters should have another application. When a range is once infested, it is necessary to repeat the copper sulfate treatment once a year until all snails are killed off; the best time to treat is when the greatest number of snails can be reached. Usually this is after the spring rains. Oftentimes a combination of drainage and copper sulfate will bring about the desired results. Where complete drainage is either impractical or impossible, partial drainage may prove to be of value. Such partial drainage will reduce the size of the wet area and the remaining undrained portion can then be treated with copper sulfate. The method or methods to be used and the extent to which each one or both can be used will depend entirely upon local conditions.

The Large Liver Fluke

Location.—The large liver fluke, *Fascioloides magna*, is found in the tissues of the liver, commonly lying in cysts which, in addition to the flukes, usually contain a quantity of dark-colored fluid and debris.

Appearance.—The large liver fluke, like the common liver fluke, is a flattened leaflike brown worm. It may attain a length of 7 centimeters (2¾ inches). The anterior or front sucker is not carried on a distinct cone, but in other respects the large liver fluke resembles an overgrown specimen of the common liver fluke.

Life history.—The life history of the large liver fluke is essentially the same as that of the common liver fluke, *Fasciola hepatica*. The snails which serve as intermediate hosts of the common liver fluke also serve as intermediate hosts of the large liver fluke and the development in the snail is the same for both species. The main difference in the life histories of these flukes lies in the fact that cattle apparently do not serve as spreaders of *Fascioloides magna*. The

mature flukes are found in cysts in the liver tissue. These cysts are heavily walled and apparently do not permit the egress of the fluke eggs to the bile ducts and thence to the small intestine. The encysted flukes die in the liver and their eggs do not reach the outside.

So far as known, deer and sheep serve as the principal propagators of this fluke.

Distribution.—The large liver fluke appears to be indigenous to North America. It occurs in cattle in Texas, Louisiana, and Arkansas, in the upper peninsula of Michigan, and along the Pacific Coast of the United States and Canada, and has been reported from New York, Colorado, Montana, and Minnesota.

Symptoms and lesions.—The symptoms of infestation of the large liver fluke are similar to those associated with infestation of the common liver fluke. The lesions consist of the characteristic cysts, which resemble abscesses.

Treatment.—Owing to the fact that eggs of the large liver fluke are rarely if ever found in the feces, diagnosis of the infestation cannot be made with certainty, and no satisfactory treatment is yet known.

Prevention and control.—The control measures discussed under the common liver fluke also apply to the control of the large liver fluke.

The Rumen Flukes

Location.—The rumen flukes, *Cotylophoron cotylophorum* and *Paramphistomum cervi*, are found in the rumen or paunch of cattle, usually near the opening of the paunch into the reticulum or honeycomb stomach.

Appearance.—These small flukes are about one-fifth to one-half of an inch in length. The bodies are pinkish when alive, are convex dorsally, and slightly concave ventrally. Their general shape is more or less like a cone; broad and blunt at the posterior end, and rather pointed at the front or anterior end.

Life history.—The life history of one of these flukes, *Cotylophoron cotylophorum*, has been reported in detail and found to be essentially the same as that of the common liver fluke. The snails which serve as intermediate hosts of the common liver fluke also serve as intermediate hosts of the rumen flukes.

In South Africa one investigator reports the occurrence of the immature stages of *Cotylophoron cotylophorum* in the duodenum of sheep. This investigator expresses the opinion that the immature forms, after spending some time in the duodenum, migrate to the rumen and reach maturity in that organ.

Distribution.—This fluke is of rather common occurrence in cattle in Louisiana and it is probably well distributed throughout the Southern States. Records of the occurrence of this fluke are available from such widely separated areas as Louisiana, New York, and North Dakota.

Symptoms and lesions.—The adult parasites appear to be relatively harmless and no definite lesions have been ascribed to them. However, it has lately been reported that the immature stages are very definitely harmful. The symptoms described are very similar to those of roundworm infestation and the lesions occur chiefly in the small intestine through which the immature stages pass before finally reaching the rumen. The animals infected with the immature stages

of these flukes showed on post mortem examination a marked congestion of the blood vessels of the anterior part of the small intestine and a marked thickening of the wall of the gut at this particular point. The conclusion is drawn that the adult parasite, when located in the rumen may be considered harmless, but the immature stages are decidedly harmful.

Treatment.—South African authorities recommend the use of carbon tetrachloride for the treatment of animals infested with rumen flukes. For these flukes, it is advisable to use carbon tetrachloride in the same doses as given under the treatment for liver fluke combined with ½ to 1 pint of mineral oil or immediately followed by a suitable dose of Glauber's salt. The same feeding precautions outlined in connection with liver fluke treatment should be observed in the case of carbon tetrachloride administration for the rumen flukes. Lactating animals should not be treated with this drug.

Prevention.—Since snails act as intermediate hosts of these parasites, the methods of prevention advocated in the case of the liver fluke may prove to be beneficial.

PROTOZOAN PARASITES OF CATTLE

A large number of Protozoa have been reported as parasites of cattle, but only a few of these are known to be harmful. They are all minute parasites, too small to be seen with the naked eye.

Coccidia

A number of species of coccidia all belonging to the genus *Eimeria* but varying greatly in size and certain other morphological characters, have been reported as parasites of cattle. One of the most important of these is *Eimeria zurni*. This parasite occurs in the wall of the large intestine of cattle, especially of calves, and causes a disease known as coccidiosis, commonly referred to as bloody diarrhea.

Appearance.—The resting or spore form of this parasite, which is the form usually found on microscopical examination of fecal specimens, is ovoid in shape and about four to five times as large as a red blood cell, or about one one-thousandth of an inch long.

Life history.—The life history of this parasite is very complicated. The resting or spore forms, known as oöcysts, pass out of the body with the manure. Under favorable conditions there develop within the oöcyst four bodies known as sporocysts. Within each sporocyst there develop two sporozoites, so that at maturity the oöcyst contains eight sporozoites. This is the infective stage of the parasite. When taken up by a susceptible animal on feed or in water, these sporozoites are liberated in the intestine and they invade the wall of this organ. The preferred site in which the parasite undergoes its development is in the cells composing the inner lining of the large intestine; to a very much lesser extent it develops in the cells lining the small intestine. Here the parasites multiply, at first asexually and later sexually. At the beginning of an infection the asexual cycle is more prevalent, whereas later on the sexual forms are more frequently found. The sexual reproduction results in the formation of oöcysts which pass out of the body with the manure and which, after maturing outside of the body, again become able to infect a new host.

DISTRIBUTION.—Coccidiosis, which is the name given to the disease caused by these parasites, appears to be widespread throughout the United States.

SYMPTOMS AND LESIONS.—The first symptom noticed is a bloody diarrhea. In the early stages the blood is on the outside of the fecal mass, but as the disease progresses and the feces become more diarrheal the blood may be mixed throughout the fecal mass. Affected animals are dull, lie down a great deal, eat little or nothing, and become emaciated very rapidly. The skin becomes tight, the hair coat rough, the abdomen assumes a tucked-up appearance, and the tail and buttocks are stained with feces. Peristalsis is diminished, and the feces become watery and scanty and are passed with a great deal of straining. The pulse and temperature may be slightly increased. Depending upon the severity of the attack, the post mortem lesions are: A catarrhal condition of the small intestine with congestion and thickening of the wall of the cecum and colon; or in severe cases the mucous membrane lining the walls of the cecum, colon, and rectum is red and shows numerous small hemorrhages.

DURATION AND COURSE OF THE DISEASE.—In young animals the acute manifestations usually last for about 10 to 12 days. In severe cases death may occur in a few days. In the cases that recover the period of convalescence lasts several weeks, depending upon the severity of the initial infection. Recovered cases usually become chronic carriers, that is, they continue to discharge oöcysts for a long time.

TREATMENT.—Calves affected with coccidiosis should be segregated in separate pens which should be cleaned and supplied with fresh bedding daily. The sick animals should be disturbed as little as possible as movement tends to increase the straining and hemorrhage. Soft nutritious foods should be given in small quantities several times a day. Milk and barley water are especially indicated. There is no satisfactory medicinal treatment for coccidiosis. Attention should be directed toward keeping up the strength of the animal and controlling symptoms as they appear. Intestinal astringents are used to control the diarrhea and prevent severe hemorrhage. Rectal injections of such drugs appear to be most useful. For this purpose, ichthargan, a silver preparation, may be used in the proportion of 1 gram dissolved in 1 quart of boiled water, or tannic acid in the proportion of 1 gram in 100 cubic centimeters (3 ounces) of boiled water, injected deeply into the rectum.

PREVENTION.—As calves are the most severely affected and as the disease is spread by means of oöcysts which are very resistant to unfavorable external conditions, the efforts at prevention should be directed toward keeping calves away from sources of infection in areas where the disease is prevalent.

However, it has recently been reported that coccidia frequently occur in the feces of normal, healthy cattle, and that clinical outbreaks of coccidiosis occur chiefly in calves following some sudden change in feed, or environmental or climatic conditions. It is thought that the lowered vitality resulting from such changes or exposures reduces the normal resistance of the host animal which favors an increase in the number of parasites and the consequent production of a disease condition. It is obvious that in these cases the best method of prevention consists in avoiding, whenever possible, the conditions which may render the animal subject to attack.

Trichomonads

Two species of Trichomonas, namely, *T. ruminantium* and *T. foetus* have been reported as parasites of cattle. *T. ruminantium* is a common parasite of the digestive tract. It has been found in association with cases of diarrhea in cattle, but, so far as known, does not bear any causal relationship to this condition.

TRICHOMONAS FOETUS

Location.—*Trichomonas foetus* is found in the generative organs of cattle suffering from genital trichomoniasis.

Appearance.—*Trichomonas foetus* is a one-celled microscopic organism varying in length from 10 to 25 microns and in width from about 8 to 10 microns. (A micron is one-twenty-five-thousandth inch.) It has 3 anterior flagella, each about as long as the body (fig. 9), and a posterior flagellum (a whiplike appendage) constituting marginal filament of the undulating membrane and projecting posteriorly beyond the membrane as a free flagellum; the latter is about

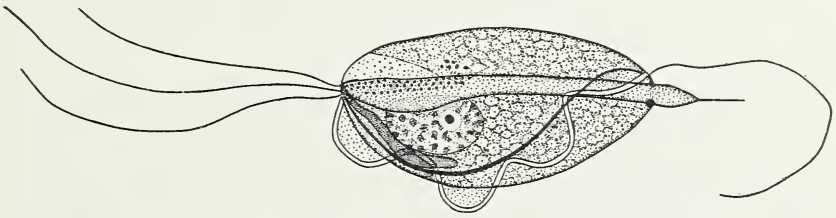

Figure 9.—The one-celled micro-organism, *Trichomonas foetus*. (Greatly magnified.)

as long as the anterior flagella. There is a dorsally placed undulating membrane extending almost the entire length of the body; this membrane exhibits four to five undulations. In general, *T. foetus* is somewhat larger than the polymorphonuclear leucocytes and somewhat smaller than the epithelial cells commonly found in vaginal smears. When examined alive the organism is actively motile. It moves across the field of vision of the microscope with an undulating motion; at times it turns and twists and assumes varying shapes. It may appear pear-shaped, oval, or rounded. The rapidity of its movements depends to some extent on the medium in which it is examined. When studied in a drop of physiologic saline, the movements of *T. foetus* are rather rapid, but in a collection of somewhat tenacious vaginal mucus the movements are considerably restricted.

Life history.—The organism reproduces by division, each organism splitting and dividing into two. It is usually transmitted from one animal to another by coitus.

Distribution.—*Trichomonas foetus* is widely distributed throughout the United States.

Symptoms and lesions.—As a result of infection one of several things may happen: (1) The animal may fail to conceive; (2) conception may take place but owing to uterine infection there may be abortion; (2) following conception the fetus may die but instead of being expelled it may become macerated, and the uterus may become

filled with a characteristic thin, grayish-white, almost odorless fluid; or (4) a normal gestation and parturition may occur in spite of infection.

Animals which fail to conceive may develop a uterine infection manifested by a vaginal discharge which may be continuous or intermittent. Estrual periods may become irregular due to infection with *Trichomonas foetus* and the discharge may be most marked at this time.

Abortion due to trichomoniasis may occur at any time during the period of gestation, but it usually takes place in from 8 to 16 weeks after conception. There are usually no signs of estrum during this period. A few days before abortion there is often a vaginal discharge indicating the approaching abortion. At times only a small quantity of whitish mucoid fluid is expelled instead of the fetus. The abortion may pass unobserved, especially if it occurs at night, in a dark stable, or on pasture. A few days after such an abortion the animal usually comes in heat and this is often the first indication of infection.

In cases where the fetus becomes macerated and not expelled the animals generally behave like those normally pregnant. They show no signs of illness, but the usual outward signs normally indicating approaching parturition fail to appear. At the end of the period of gestation there is no calf, and on examination the uterus is found to be filled with fluid.

Inflammation of the prepuce accompanied by pus formation and discharge has been reported in recently infected bulls. In such cases, examination of the preputialm ucosa and penis are found to be inflamed and to contain many small nodules similar to those occurring in bulls affected with nodular venereal disease. Trichomonads have been reported as occurring in the epididymis and in the ampullae of the vas deferens where these enter the urethra; they have also been found in the anterior portion of the urethra. The infection usually becomes chronic in bulls.

Trichomonas foetus has been reported as occurring in the vagina of virgin heifers and in the prepuce of a young bull which, so far as known, had never been used for breeding purposes.

Diagnosis.—The diagnosis of trichomoniasis is based, in part, on the breeding history of the herd and of affected animals within the herd. However, the demonstration of the organism in vaginal or uterine discharges is necessary to make the diagnosis complete. The immediate microscopic examination of material taken from the vagina is the most direct method of making a diagnosis. For this purpose a cotton swab, moistened with physiologic saline, is introduced into the vagina and the material adhering to the swab is placed on a slide and immediately examined under the low power of the microscope. If the organisms are present there is no difficulty in recognizing them. In case no microscope is available the contents of the swab can be washed into a tube of physiologic saline, a few drops of Lugol's solution of iodine or 10 percent formalin solution added, the tube tightly closed, and then sent to a laboratory for examination. Where facilities are available and direct microscopic examination fails to reveal the organisms, culturing the material removed from the vagina may prove to be of great assistance. This will often show the presence of the organisms when they are too few to be detected by direct examination.

A similar procedure may be followed in bulls. The cotton swab moistened in physiologic saline, is introduced into the sheath and then examined in the same manner as the vaginal swab. It must be remembered, however, that a negative examination is by no means conclusive and it may be necessary to make several examinations extending over a considerable period. So far as cows and heifers are concerned, the best time for an examination appears to be during the estrual periods. Vaginal examination of a cow or heifer in from 7 to 21 days after service has been suggested as a means of determining whether the bull used is transmitting the infection. If the bull used is transmitting trichomoniasis, the infection in the cow will be vaginal and can be demonstrated at that time. The diagnosis, therefore, is made on the basis of the breeding history of the individual animal and of the herd, and the demonstration of the presence of the organism.

Treatment.—There is no specific treatment, the disease being handled as any other form of genital infection in cattle.

Cows that abort early in the period of gestation usually recover spontaneously provided the abortion is complete and the animals are given a period of sexual rest for about 3 months. If the abortion is incomplete and there is a persistent discharge, the animals should be handled as cases of uterine infection due to other causes. This also applies to cases of pyometra. In some cases of pyometra the cervix relaxes when the end of the normal gestation period approaches and there is discharge of uterine contents. In other cases the cervix remains tightly closed and the only way of making a diagnosis is by manual examination per rectum. In these cases the uterus should be emptied and douched in the usual manner. Whether such animals will return to breeding efficiency will depend upon the extent of the damage to the uterine mucosa.

Cows that fail to conceive after repeated services, as a result of trichomonad infection, should be given sexual rest until the estrual cycle returns to normal. They should receive such treatment as is indicated, that is, uterine and vaginal douches, ovarian massage, and removal of yellow bodies when present. This treatment should be administered by a competent veterinarian.

From a herd viewpoint the disease can be considered as an infectious vaginitis and metritis carried and transmitted by bulls; the herd and the individual animals in it should be treated from that viewpoint.

Infected bulls have been considered as incurable and their destruction as a means of eliminating sources of infection has been advocated. This advice, while theoretically sound, is not always practical. A treatment which has been used in a few cases with apparent success has been described. This treatment consists in casting the animal, unsheathing the penis under epidural anesthesia and injecting from 50 to 100 cubic centimeters of a 0.1-percent solution of trypaflavine into the urethra and rubbing a 0.5-percent trypaflavine ointment into the inner surface of the prepuce. The treatment should be repeated in a week.

Douching the sheath of the bull before and after service has also been recommended.

Prevention.—As the disease is spread principally by coitus, the utmost caution should be exercised in the introduction of mature animals as permanent additions to the herd. The breeding histories

of all such animals, whether male or female, and the breeding histories of the herds from which they come should be carefully examined. Cows known as hard or difficult breeders should not be brought to the premises for breeding purposes unless it can be definitely determined that they are not infected with trichomoniasis. Cows known to be free from trichomoniasis should not be bred away from home. They may acquire the disease in the process and later serve as sources of infection to animals in the herd to which they are returned. In herds in which the infection has become established the use of infected bulls should be restricted to cows which have either passed through an attack of the disease or which have at least been previously exposed to the disease. Cases of trichomonad infection in virgin heifers have been explained on the theory that infection was acquired by contact with infected animals. There is no experimental evidence that such contact infection can occur, but until the question is definitely settled it is advisable that calves and heifers be definitely separated from animals that are known to be infected.

PARASITES OF THE BLOOD OF CATTLE

Babesia Bigemina (Piroplasma Bigeminum) and B. Argentina

Of the two diseases of cattle in the United States caused by parasites in the blood, the one best known to stockmen is piroplasmosis, or cattle-tick fever. This is an infectious disease characterized by high fever, increased respiration, rapid pulse, marked depression, loss of appetite, suppression of rumination and milk flow, severe anemia resulting from destruction of the red blood cells, and hemoglobinuria, or bloody urine. This disease is caused by two organisms known as *Babesia bigemina* (*Piroplasma bigeminum*) (fig. 10), and *Babesia argentina* (fig. 11), which live in the blood and attack the red blood corpuscles. These organisms are transmitted to cattle by the ticks, *Boophilus annulatus* and *B. annulatus* var. *microplus*.

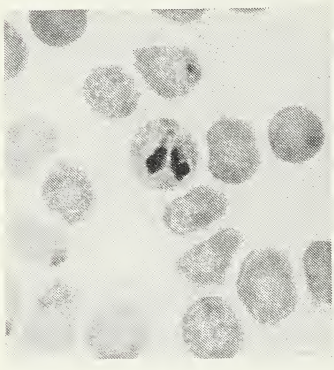

Figure 10.—*Babesia bigemina* (*Piroplasma bigeminum*), (dark bodies in center of blood cell) the cause of tick fever in cattle. (Magnified 1,500 times.)

Location.—The parasites causing tick fever are usually located in the red blood cells, although occasionally some may be found in the plasma outside of the red blood cells.

Appearance.—While these organisms may assume various shapes, their most characteristic form in properly fixed and stained smears made from the blood of infected cattle is that of oval to pear-shaped bodies. These bodies may occur singly or in pairs and at times more than one pair may be found in a red blood cell. *Babesia bigemina* is usually somewhat larger than *B. argentina* and the mean angle of divergence between the members of a pair is usually greater in *B. argentina* than in *B. bigemina*. There is, however, considerable overlapping both in the size of these organisms and in the angle of diver-

sion. *B. bigemina* occurs most abundantly in the blood of the peripheral circulation and *B. argentina* in that of the systemic circulation.

LIFE HISTORY.—The organisms causing tick fever multiply in the blood of infected animals but, under natural conditions, can pass from

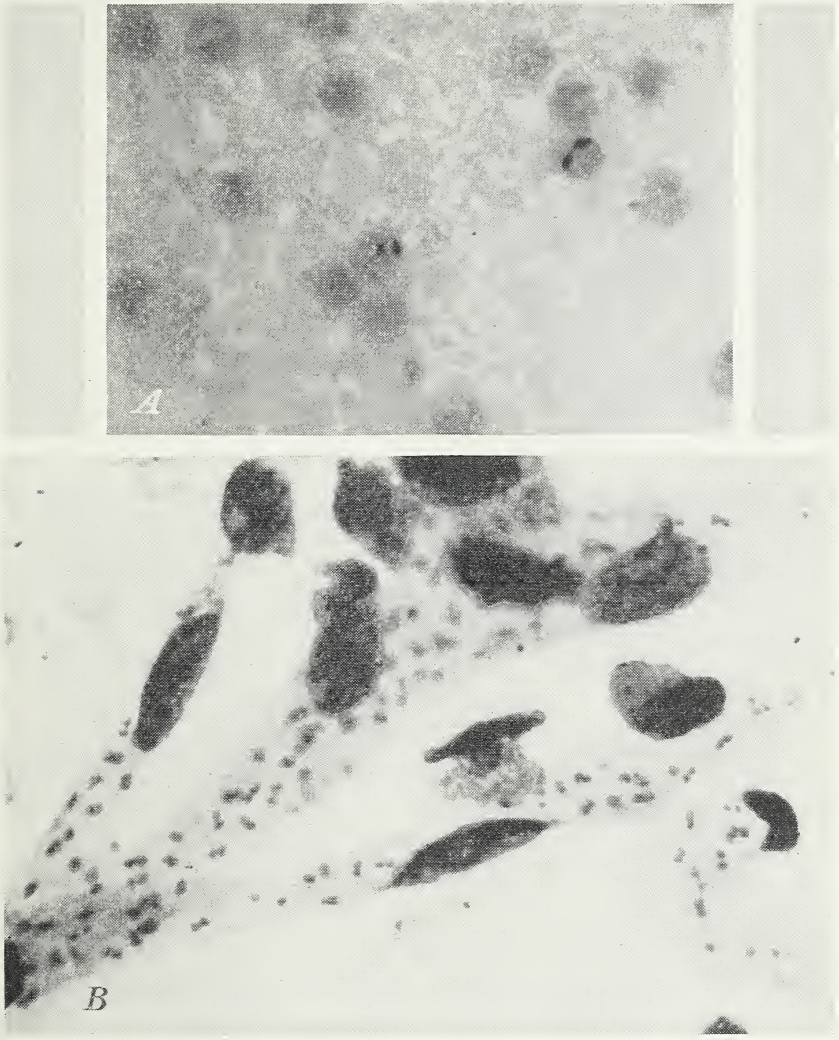

FIGURE 11.—*Babesia argentina*, another cause of tick fever of cattle: *A*, Organisms (pairs of dark bodies in blood cells) in heart blood; *B*, organisms in blood vessel of the brain. (Magnified 1,500 times.)

one animal to another only through the intermediacy of certain ticks. They gain entrance into the body of the tick when the tick sucks the blood of an infected cow. In the body of the tick the organisms undergo certain changes and then pass into the eggs of tick and remain in the larvae or seed ticks of the next generation. In the seed ticks the organisms are found in the salivary glands and when

these seed ticks become attached to a susceptible bovine and begin to suck blood, the organisms pass from the ticks into the blood of the animal on which the ticks are engorging. The organisms which cause tick fever are transmitted from one cow to another not by the ticks which take up the infected blood but by the ticks of the next generation. Further details concerning tick fever and cattle-fever ticks are discussed in Farmers' Bulletin No. 1625. The control and eradication of fever ticks, *Boophilus annulatus*, by dipping and other methods are described in Farmers' Bulletin No. 1057. The information furnished in those bulletins concerning *Boophilus annulatus* applies also to *B. annulatus* var. *microplus*.

Distribution.—As a result of the tick eradication campaign begun in 1906, the cattle-fever ticks and tick fever have been practically eliminated from the United States. Only a narrow strip of territory along the Rio Grande in southeastern Texas and a small area in southern Florida were considered as tick-infested areas as of December 1, 1940.

Treatment.—Trypan blue administered intravenously in a dose of 100 cubic centimeters of a 1-percent solution in physiologic saline or the same quantity of dye incorporated in 500 cubic centimeters of physiologic saline has given good results in cases of tick fever due to *Babesia bigemina*, but this drug is totally ineffective in the treatment of cases of tick fever due to *Babesia argentina*. A drug, known by the proprietary name of acaprin has been reported as effective in the treatment of tick fever in cattle due to *Babesia bigemina* and also in cases of tick fever due to other species of Babesia. This drug is administered subcutaneously and appears to have several advantages over other drugs recommended by various authors. It does not stain the tissues, the quantity required is small, and the method of administration is easy and simple.

Anaplasma Marginale

The other disease of the blood of cattle is known as anaplasmosis. In stained preparations of the blood of cattle suffering from this disease there are found, usually near the margin of the red blood cells, certain deeply staining bodies called *Anaplasma marginale*.

Location.—The bodies known as *Anaplasma marginale* are located near the margin of the red blood cells of cattle suffering from anaplasmosis (fig. 12).

Appearance.—When properly stained these bodies appear like small rounded dots (fig. 12) about 1 micron in diameter.

Distribution.—Anaplasmosis is now known to exist in the following States: Alabama, Arizona, Arkansas, California, Colorado, Delaware, Florida, Georgia, Idaho, Kansas, Louisiana, Maryland, Mississippi, Missouri, Montana, Nevada, Ohio, Oklahoma, Oregon, Texas, Virginia, and Wyoming. The disease is probably present, though unrecognized in other States. It is not necessarily confined to warm climates as several of the localities mentioned have low winter temperatures.

Symptoms and lesions.—The symptoms of anaplasmosis are similar to those of tick fever. The first symptoms are cessation of rumination, diminished milk secretion, unsteady gait, and a tendency to lie down frequently. The pulse is increased and the respiration is

short and rapid. The temperature is high, ranging between 104° and 106° F. and continuing for several days. Owing to the great destruction of blood cells, the visible mucous membranes are pale and may be tinged with yellow. The animals lose flesh rapidly and the eyes appear sunken. Recovery is very slow, the period of convalescence often lasting for several months. The death rate is variable, in some outbreaks being as high as 50 percent.

The changes in the internal organs, as found on post mortem examination, are similar to those seen in tick fever, except that there is, as a rule, no bloody urine. The blood is pale and watery, the spleen greatly swollen and soft, the liver bile-colored, and the fat and the connective tissues have a yellow tint. Small hemorrhagic spots are seen on the heart, and the heart muscle has a cooked appearance.

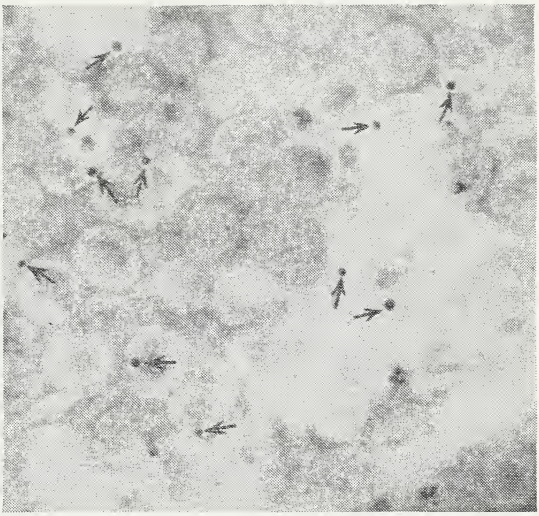

FIGURE 12.—*Anaplasma marginale* (the small dark bodies), which are the cause of anaplasmosis of cattle. The larger, disk-shaped bodies are the blood cells. (× 1,500.)

Experimentally the disease has been transmitted by various species of ticks and flies. It can also be transmitted mechanically by unclean surgical instruments.

TREATMENT.—Medical treatment is so far of little value. Animals suffering from anaplasmosis should be kept in a cool, quiet place and disturbed as little as possible. They should be given plenty of clean water, a little green feed, and protected against fly annoyance. Unnecessary driving and rough handling should be avoided. As most animals sick with anaplasmosis suffer from constipation, the use of a cathartic appears to be indicated. Drastic treatment, however, should be avoided.

PREVENTION.—In areas where the disease is prevalent great care should be taken that in operations involving numbers of animals, such as dehorning and bleeding for the Bang's disease test, absolutely clean instruments be used for each animal.

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